Relationships Between two Port Parameters

① Relationship between Z-Parameter & Y-parameter.

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

- this two equation can be written as

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$[V] = [Z] [I] \longrightarrow ①$$

and Y-Parameter

$$I_1 = y_{11} V_1 + y_{12} V_2$$
$$I_2 = y_{21} V_1 + y_{22} V_2$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$[I] = [Y] [V] \longrightarrow ②$$

su بالتعويض من ② في ①

$$\therefore [\cancel{V}] = [Z] [Y] [\cancel{V}]$$

$$[Z][Y] = 1 \rightarrow ③$$

From ③ $\quad [Z] = [Y]^{-1}$

inverse لايجاد الـ

$$[Y] = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$$Y^T = \begin{bmatrix} y_{11} & y_{21} \\ y_{12} & y_{22} \end{bmatrix}$$

$$Y^a = \begin{bmatrix} y_{22} & -y_{12} \\ -y_{21} & y_{11} \end{bmatrix}$$

$$\Delta Y = \begin{vmatrix} y_{21} & y_{12} \\ y_{21} & y_{22} \end{vmatrix} = y_{11} y_{22} - y_{12} y_{21}$$

$$\therefore [Y^{-1}] = \frac{1}{\Delta y} \overbrace{\begin{bmatrix} y_{22} & -y_{12} \\ -y_{21} & y_{11} \end{bmatrix}}^{Y^a} = \begin{bmatrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{bmatrix}$$

$$\therefore \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{bmatrix}$$

$$Z_{11} = \frac{y_{22}}{\Delta y}, \quad Z_{12} = \frac{-y_{12}}{\Delta y}, \quad Z_{21} = \frac{-y_{21}}{\Delta y}, \quad Z_{22} = \frac{y_{11}}{\Delta y}$$ //

Relationship between Y-Parameter and Z-Parameter.

→ From equation 3

$$[Y] = [Z]^{-1}$$

$$[Z] = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$$

$$Z^{T} = \begin{bmatrix} Z_{22} & Z_{21} \\ Z_{12} & Z_{22} \end{bmatrix} \quad \& \quad Z^{a} = \begin{bmatrix} Z_{22} & -Z_{12} \\ -Z_{21} & Z_{11} \end{bmatrix}$$

$$\Delta Z = \begin{vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{vmatrix} = Z_{11} Z_{22} - Z_{12} Z_{21}$$

$$\therefore [Z]^{-1} = \frac{1}{\Delta Z} \begin{bmatrix} Z_{22} & -Z_{12} \\ -Z_{21} & Z_{11} \end{bmatrix} = \begin{bmatrix} \frac{Z_{22}}{\Delta Z} & \frac{-Z_{12}}{\Delta Z} \\ \frac{-Z_{21}}{\Delta Z} & \frac{Z_{11}}{\Delta Z} \end{bmatrix}$$

$$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{Z_{22}}{\Delta Z} & -\frac{Z_{12}}{\Delta Z} \\ -\frac{Z_{21}}{\Delta Z} & \frac{Z_{11}}{\Delta Z} \end{bmatrix}$$

$$y_{11} = \frac{Z_{22}}{\Delta Z} \quad \& \quad y_{12} = \frac{-Z_{12}}{\Delta Z} \quad \& \quad y_{21} = -\frac{Z_{21}}{\Delta Z} \quad \& \quad y_{22} = \frac{Z_{11}}{\Delta Z}$$

Relation between h-Parameter and Z-Parameter and y-Parameter

$$V_1 = h_{11} I_1 + h_{12} V_2 \rightarrow (1)$$
$$I_2 = h_{21} I_1 + h_{22} V_2 \rightarrow (2)$$

from (1) $\quad h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0} \quad V_2 = 0$ short circuit

→ in Y-Parameter equations.

$$I_1 = y_{11} V_1 + y_{12} V_2 \Rightarrow \frac{I_1}{V_1}\Big|_{V_2=0} = y_{11}$$

$$\therefore \frac{V_1}{I_1}\Big|_{V_2=0} = \frac{1}{y_{11}} = h_{11}$$

$$\therefore \boxed{h_{11} = \frac{1}{y_{11}} = \frac{\Delta Z}{Z_{22}}}$$

→ $h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0}$ open circuit

from Z-Parameter's equations

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \xRightarrow{I_1=0} V_1 = Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2 \Rightarrow V_2 = Z_{22} I_2$$

∴ divided two equations $\quad h_{12} = \frac{V_1}{V_2} = \frac{Z_{12}}{Z_{22}}$

$$\therefore \boxed{h_{12} = \frac{V_1}{V_2} = \frac{Z_{12}}{Z_{22}}}$$

$$h_{12} = \frac{-y_{12}}{\cancel{\Delta y}} * \frac{\cancel{\Delta y}}{y_{11}} = \frac{-y_{12}}{y_{11}} \leftarrow \boxed{\therefore h_{12} = \frac{-y_{12}}{y_{11}}}$$

$$h_{21} = \frac{I_2}{I_1}\Big|_{V_2=0} \qquad V_2 = 0 \quad \text{Short circuit}$$

From y- Parameter equation

$$I_1 = y_{11} V_1 + y_{12} V_2 \xRightarrow{V_2=0} I_1 = y_{11} V_1$$
$$I_2 = y_{21} V_1 + y_{22} V_2 \Longrightarrow I_2 = y_{21} V_1$$

$$\frac{I_2}{I_1}\Big|_{V_2=0} = \frac{y_{21}}{y_{11}} = h_{21}$$

$$\therefore \boxed{h_{21} = \frac{y_{21}}{y_{11}}}$$

$$h_{21} = -\frac{Z_{21}}{\Delta Z} \times \frac{\Delta Z}{Z_{22}} = -\frac{Z_{21}}{Z_{22}}$$

$$\boxed{h_{21} = -\frac{Z_{21}}{Z_{22}}}$$

$$\Rightarrow h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0} \qquad I_1 = 0 \quad \text{open circuit}$$

From Z-Parameter equations

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \xRightarrow{I_1=0} V_2 = Z_{22} I_2$$

$$\therefore \frac{I_2}{V_2}\Big|_{I_1=0} = \frac{1}{Z_{22}} = h_{22}$$

$$\boxed{h_{22} = \frac{1}{Z_{22}}} \qquad \boxed{h_{22} = \frac{\Delta y}{y_{11}}}$$

– Relation between Z-Parameter and h-Parameters.

h-Parameter

$$V_1 = h_{11} I_1 + h_{12} V_2$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

Z-Parameter

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

$$\rightarrow Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0}$$

بالتعويض في معادلات h عند $I_2=0$

$$V_1 = h_{11} I_1 + h_{12} V_2$$

بالتعويض

$$0 = h_{21} I_1 + h_{22} V_2 \Rightarrow \boxed{V_2 = -\frac{h_{21}}{h_{22}} I_1}$$

$$V_1 = h_{11} I_1 + h_{12} \left(-\frac{h_{21}}{h_{22}}\right) I_1$$

$$V_1 = \left[h_{11} - \frac{h_{12} h_{21}}{h_{22}}\right] I_1$$

$$V_1/I_1 = \frac{h_{11}h_{22} - h_{12}h_{21}}{h_{22}} \qquad \Delta h = h_{11}h_{22} - h_{12}h_{21}$$

$$\therefore \boxed{Z_{11} = \frac{\Delta h}{h_{22}}}$$

Scanned by CamScanner

$$\Rightarrow Z_{12} = \frac{V_1}{I_2}\Big|_{I_1=0}$$

بالتعويض في معادلة h- Parameter

$$I_2 = h_{21} I_1 + h_{22} V_2 \xrightarrow{I_1=0} I_2 = h_{22} V_2$$

$$V_1 = h_{11} I_1 + h_{12} V_2 \Rightarrow V_1 = h_{12} V_2$$

$$\therefore \boxed{\frac{V_1}{I_2} = \frac{h_{12}}{h_{22}} = Z_{12}}$$

$$\therefore \boxed{Z_{12} = \frac{h_{12}}{h_{22}}}$$

$$\Rightarrow Z_{21} = \frac{V_2}{I_1}\Big|_{I_2=0}$$

بالتعويض في معادلة h- Parameter مع $I_2=0$

$$I_2 = h_{21} I_1 + h_{22} V_2$$

$$0 = h_{21} I_1 + h_{22} V_2$$

$$\therefore \frac{V_2}{I_1} = \frac{-h_{21}}{h_{22}}$$

$$\therefore \boxed{Z_{21} = \frac{-h_{21}}{h_{22}}}$$

$$\Rightarrow Z_{22} = \frac{V_2}{I_2}\Big|_{I_1=0}$$

بالتعويض عن $I_1=0$ في معادلات h-Par.

$$I_2 = h_{22} V_2 \qquad \therefore \frac{V_2}{I_2} = \frac{1}{h_{22}}$$

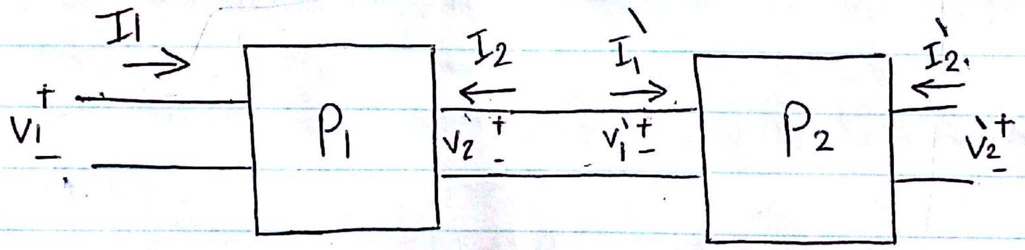
$$\therefore \boxed{Z_{22} = \frac{1}{h_{22}}}$$

Interconnection of two-ports :-

- هناك طرق عده لتوصيل دائرتين معاً منها

1- Cascade.
2- Series
3- Parallel
4- Series - Parallel
5- Parallel - series

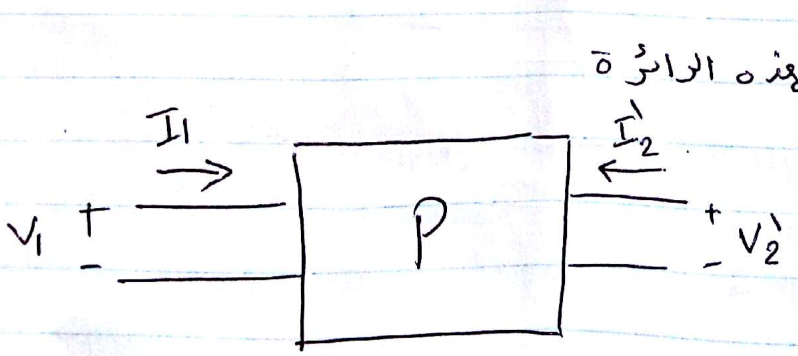
① Cascade :-



$V_2 = V_1'$
$I_2 = -I_1'$

نلاحظ من الرسم

ويمكن رسم المكافئ لهذه الدائرة



→ For P_1 :- write the Transmission

$V_1 = A\, V_2 - B\, I_2$ OR $V_1 = a_{11} V_2 - a_{12} I_2$

$I_1 = C\, V_2 - d\, I_2$ OR $I_1 = a_{21} V_2 - a_{22} I_2$

for P_1

$$V_1 = a_{11} V_2 - a_{12} I_2$$
$$I_1 = a_{21} V_2 - a_{22} I_2$$

for P_2

$$V_1' = a_{11}' V_2' - a_{12}' I_2'$$
$$I_1' = a_{21}' V_2' - a_{22}' I_2'$$

since $V_1' = V_2$, $I_2 = -I_1'$

بالتعويض في المعادلات

$$V_1 = a_{11}(a_{11}' V_2' - a_{12}' I_2') + a_{12}(a_{21}' V_2' - a_{22}' I_2')$$
$$= a_{11} a_{11}' V_2' - a_{11} a_{12}' I_2' + a_{12} a_{21}' V_2' - a_{12} a_{22}' I_2'$$
$$V_1 = (a_{11} a_{11}' + a_{12} a_{21}') V_2' + (-a_{11} a_{12}' - a_{12} a_{22}') I_2$$

$$\boxed{V_1 = (a_{11} a_{11}' + a_{12} a_{21}') V_2' - (a_{11} a_{12}' + a_{12} a_{22}') I_2} \rightarrow (1)$$

and I_1

$$I_1 = a_{21}(a_{11}' V_2' - a_{12}' I_2') + a_{22}(a_{21}' V_2' - a_{22}' I_2')$$
$$I_1 = a_{21} a_{11}' V_2' - a_{21} a_{12}' I_2 + a_{22} a_{21}' V_2' - a_{22}' I_2'$$

$$\boxed{I_1 = (a_{21} a_{11}' + a_{22} a_{21}') V_2' - I_2' (a_{21} a_{12}' + a_{22} a_{22}')}$$

(2)

from ① ، ②

$$a_{11eq} = a_{11}\, \grave{a}_{11} + a_{12}\, \grave{a}_{21}$$

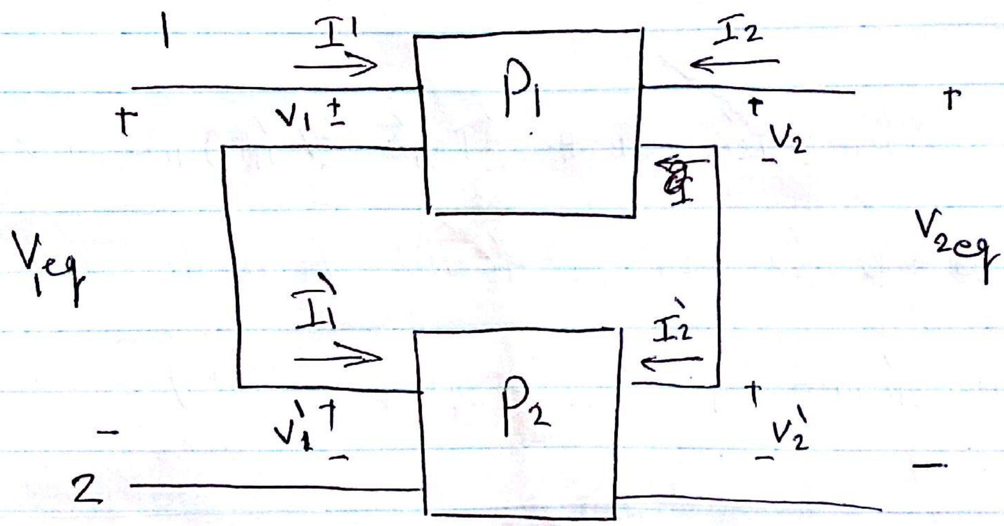
$$a_{12eq} = a_{11}\, \grave{a}_{12} + a_{12}\, \grave{a}_{22}$$

$$a_{21eq} = a_{21}\, \grave{a}_{11} + a_{22}\, \grave{a}_{21}$$

$$a_{22eq} = a_{21}\, \grave{a}_{12} + a_{22}\, \grave{a}_{22}$$

---

② Series



$$I_1 = \acute{I}_1 \quad ، \quad I_2 = \acute{I}_2$$ ربطها ثد ام

$$V_{1eq} = V_1 + V_1'$$

$$V_{2eq} = V_2 + V_2'$$

<u>For P_1:-</u>

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

For P_2

$$V'_1 = Z'_{11} I'_1 + Z'_{12} I'_2$$

$$V'_2 = Z'_{21} I'_1 + Z'_{22} I'_2$$

then

$$V_{1eq} = Z_{11} I_1 + Z_{12} I_2 + Z'_{11} I'_1 + Z'_{12} I'_2$$

$$I'_1 = I_1 \quad , \quad I'_2 = I_2$$

$$\therefore \boxed{V_{1eq} = (Z_{11} + Z'_{11}) I_1 + (Z_{12} + Z'_{12}) I_2}$$

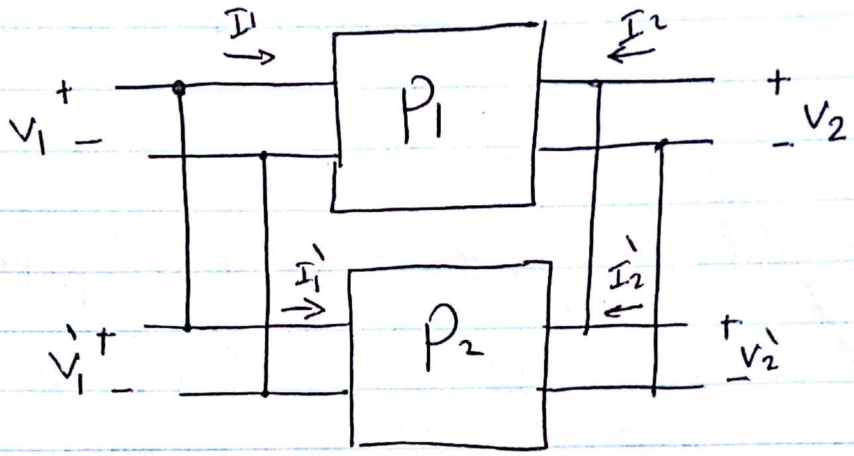
$$V_{2eq} = Z_{21} I_1 + Z_{22} I_2 + Z'_{21} I'_1 + Z'_{22} I'_2$$

$$\boxed{V_{2eq} = (Z_{21} + Z'_{21}) I_1 + (Z_{22} + Z'_{22}) I'_2}$$

$$Z_{11eq} = Z_{11} + Z'_{11} \quad , \quad Z_{12eq} = Z_{12} + Z'_{12}$$

$$Z_{21eq} = Z_{21} + Z'_{21} \quad , \quad Z_{22eq} = Z_{22} + Z'_{22}$$

③ Parallel:-



$V_1 = V_1'$ & $V_2 = V_2'$

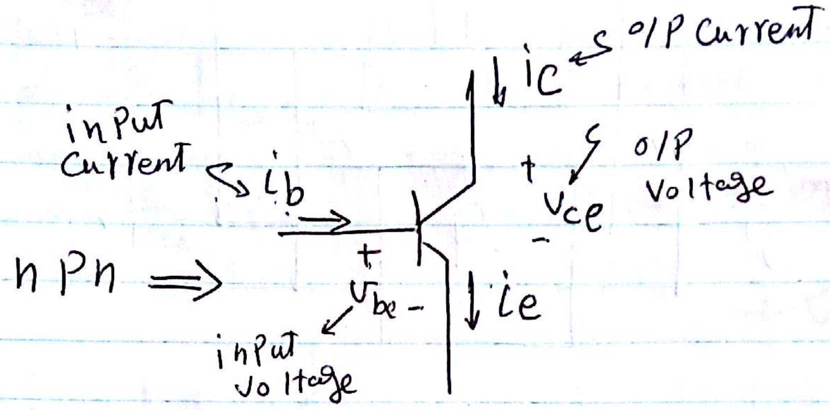
$I_{1eq} = I_1 + I_1'$, $I_{2eq} = I_2 + I_2'$

$Y_{11eq} = y_{11} + y_{11}'$ & $y_{12eq} = y_{12} + y_{12}'$

$y_{21eq} = y_{21} + y_{21}'$ & $y_{22} = y_{22} + y_{22}'$

Scanned by CamScanner

- application of the two network in small signal Transistor Amplifier



- ممكن استخدام ← h-Parameter لإستبدال الـ BJT بالدائرة المكافئة عند عملية التكبير (amplifier لإيجاد

١- معامل تكبير الجهد

٢- " " التيار

٣- " " الـ Power

⇒ h- Parameter equation :-

$$V_1 = h_{11} I_1 + h_{12} V_2$$

$$I_2 = h_{21} I_1 + h_{22} V_2$$

بالنسبة لـ BJT

$$v_{be} = h_{11} i_b + h_{12} v_{ce}$$

$$i_c = h_{21} i_b + h_{22} v_{ce}$$

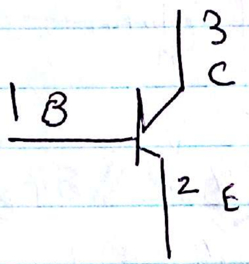
$\rightarrow h_{ie} = h_{11} = \frac{V_{be}}{I_b}\Big|_{V_{ce}=0}$ input impedance

$\rightarrow h_{re} = h_{12} = \frac{v_{be}}{v_{ce}}\Big|_{i_b=0}$ reverse voltage gain

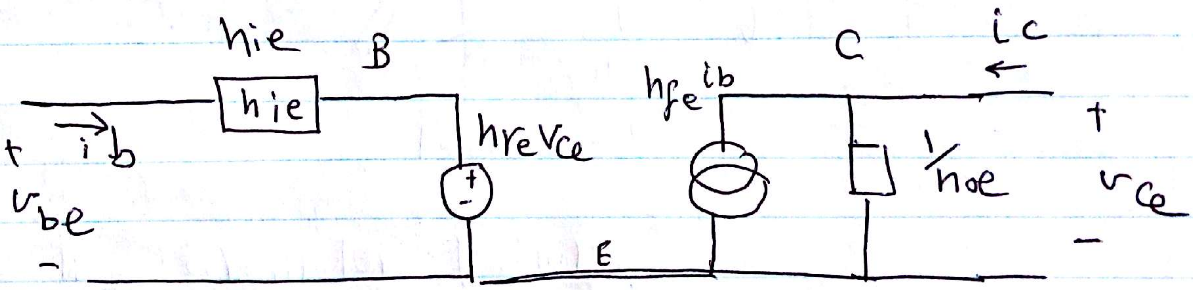
$\rightarrow h_{fe} = h_{21} = \frac{i_c}{i_b}\Big|_{V_{ce}=0}$ Forward Current gain

$\rightarrow h_{oe} = h_{22} = \frac{i_c}{v_{ce}}\Big|_{i_b=0}$ output impedance.

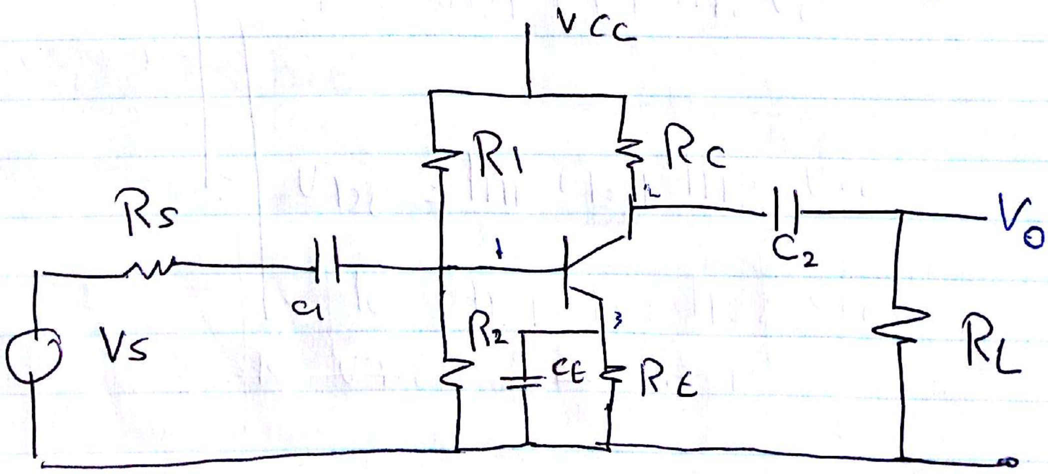
دكلوه الدائرة المكافئة



*

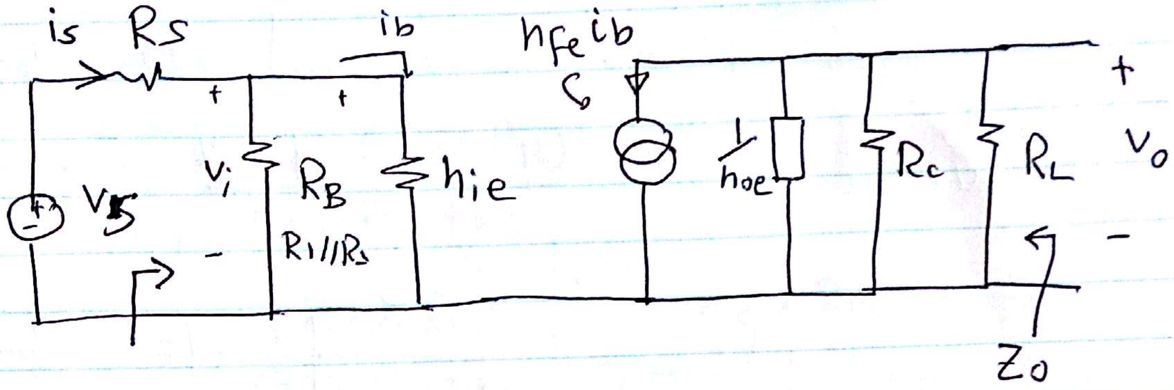


$\rightarrow$ Find The voltage gain and Current gain for



- في حالة تحليل الترانزستور في حالة التردد المتوسط .جميع المكثفات تعتبر S.C

١ الدائرة المكافئة



$$Z_i = R_s + (R_B // h_{ie})$$

$$Z_o = R_L // R_c // \frac{1}{h_{oe}}$$

* the voltage gain A_v

$$A_v = \frac{V_o}{V_i}$$

$$V_o = - h_{fe} i_b Z_o$$

$$v_i = i_b h_{ie} \Rightarrow i_b = \frac{V_i}{h_{ie}}$$

$$\therefore V_o = - h_{fe} \frac{V_i}{h_{ie}} Z_o$$

$$A_v = \frac{V_o}{V_i} = - h_{fe} \frac{Z_o}{h_{ie}}$$

overall voltage gain A_{vs}

$$A_{vs} = \frac{V_o}{V_s} = \frac{V_o}{v_i} * \frac{v_i}{v_s}$$

$$\frac{v_i}{v_s} = ??$$

$$v_i = \frac{V_s * (h_{ie} // R_B)}{(h_{ie} // R_B) + R_s}$$

$$\frac{V_i}{V_s} = \frac{(h_{ie} // R_B)}{(h_{ie} // R_B) + R_s} = \frac{\frac{h_{ie} * R_B}{h_{ie} + R_B}}{\left(\frac{h_{ie} * R_B}{h_{ie} + R_B}\right) + R_s}$$

$$\frac{V_i}{V_s} = \frac{h_{ie} * R_B}{h_{ie} * R_B + (h_{ie} + R_B) R_s}$$

$$\therefore A_{vs} = \frac{V_o}{V_i} * \frac{V_i}{V_s} = A_v * \frac{h_{ie} R_B}{h_{ie} * R_B + h_{ie} \cdot R_s + R_s R_B}$$

$$A_{vs} = A_v \frac{\cancel{R_B}\ h_{ie}}{\cancel{R_B}\left[h_{ie} + \frac{R_s}{R_B} h_{ie} + R_s\right]}$$

$$A_{vs} = A_v \frac{h_{ie}}{R_s + \frac{R_s}{R_B} h_{ie} + h_{ie}}$$

- Current gain

$$A_i = \frac{i_o}{i_i} = \frac{i_L}{i_i} = \frac{-h_{fe} Z_o}{R_L}$$

$V_o = i_o R_L$, $\boxed{i_o = \frac{V_o}{R_L}}$

$$i_{in} = \frac{v_{in}}{h_{ie}}$$

then $\frac{i_o}{i_{in}} = \frac{V_o}{V_{in}} \frac{h_{ie}}{R_o} = \boxed{A_v \frac{h_{ie}}{R_L}}$

- Total current gain :-

$$A_{I_s} = \frac{i_o}{i_s} = \frac{i_o}{i_i} * \frac{i_i}{i_s}$$

$i_i = i_s * \frac{R_B}{R_B + h_{ie}}$, $\frac{i_i}{i_s} = \frac{R_B}{R_B + h_{ie}}$.

$$\therefore A_{I_s} = A_I * \frac{R_B}{R_B + h_{ie}}$$

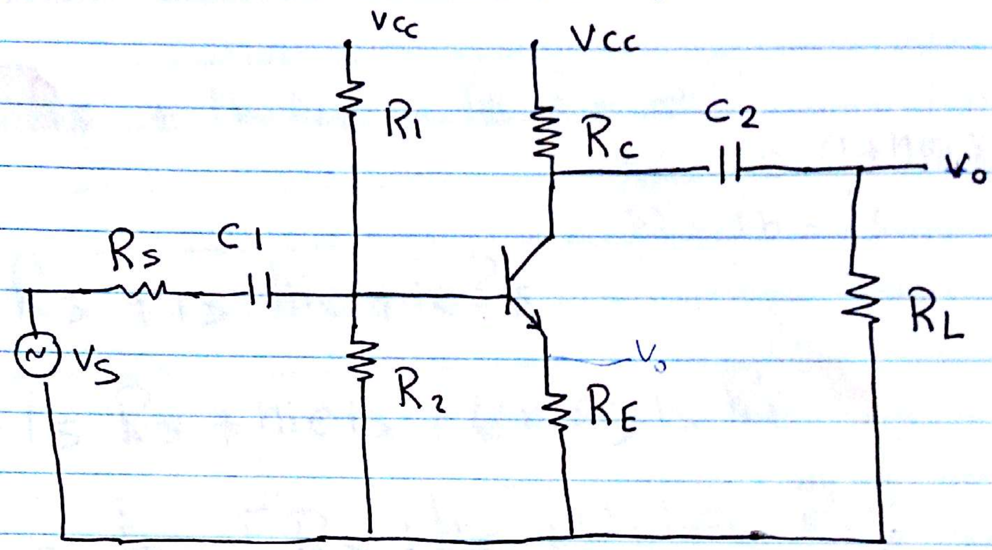
$$A_P = \frac{P_o}{P_i} = \frac{V_o i_o}{V_i i_i} = A_v A_i$$

$$A_{P_s} = A_{v_s} A_{I_s}$$

Scanned by CamScanner

H.W

- Find Z_i, Z_o, A_{vs}, A_{is} for the following network

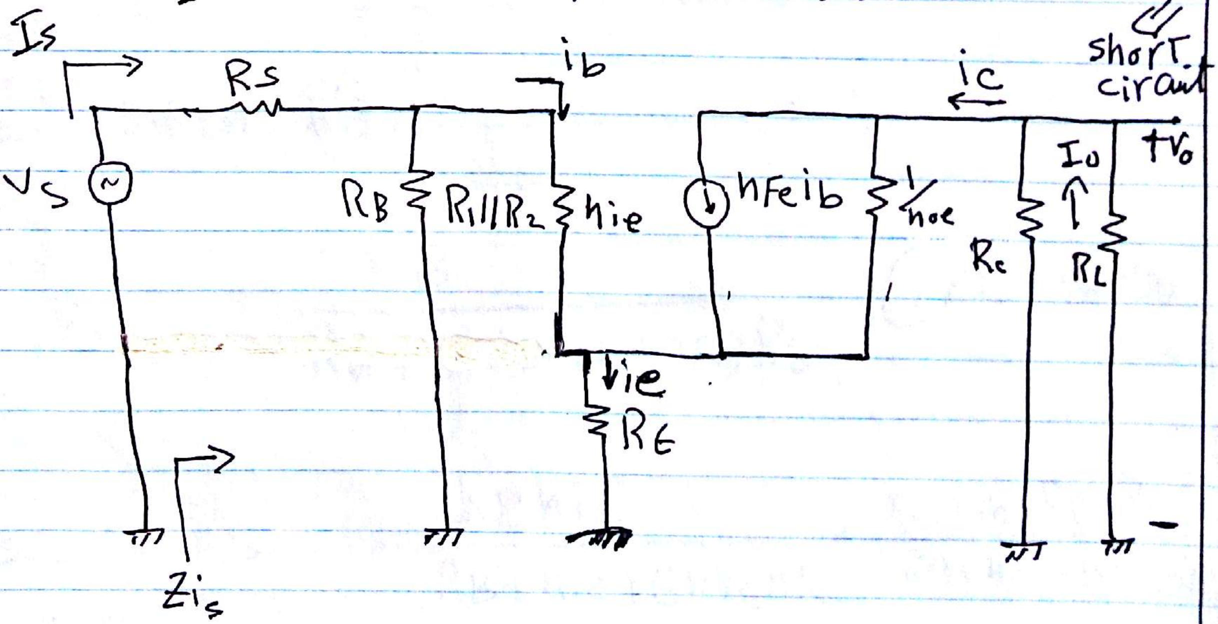


Solution

Steps

1- Put all capacitor : circuit, also dc source
short circuit

2- draw the equivalent model



to find Z_{is},

$$Z_{ins} = \frac{V_s}{I_s}$$

apply KVL around the Loop (Remove $R_B = R_1 // R_2$

$$V_s = i_s R_s + i_b h_{ie} + i_e R_E \rightarrow (1)$$

$i_e = (1+h_{fe}) i_b$

$i_b = i_s$

$$V_s = i_s R_s + i_s h_{ie} + i_e R_E$$

$$= i_s R_s + h_{ie} i_s + (1+h_{fe}) i_s R_E$$

$$\therefore V_s = i_s [R_s + h_{ie} + (1+h_{fe}) R_E]$$

$$\therefore \frac{V_s}{i_s} = Z_{ins} = [R_s + h_{ie} + (1+h_{fe}) R_E]$$

when you taken RB:-

$$i_b = i_s \frac{R_B}{R_B + h_{ie} + (1+h_{fe}) R_E}$$ بالتعويض في (1)

$$\therefore V_s = i_s R_s + i_s \frac{R_B h_{ie}}{R_B + h_{ie} + (1+h_{fe}) R_E} + \frac{(1+h_{fe}) R_B R_E i_s}{R_B + h_{ie} + (1+h_{fe}) R_E}$$

$$= i_s \left[R_s + \frac{R_B h_{ie} + (1+h_{fe}) R_B R_E}{R_B + h_{ie} + (1+h_{fe}) R_E} \right]$$

$$Z_{ins} = \frac{V_s}{i_s} = \left[R_s + [R_B // h_{ie} + (1+h_{fe}) R_E] \right]$$

to Calculate Z_o :- Remove the $\frac{1}{h_{oe}}$

$$\boxed{Z_o = R_L \parallel R_C}$$

⇒ to Calculate A_{vs}: Remove $\frac{1}{h_{oe}}$

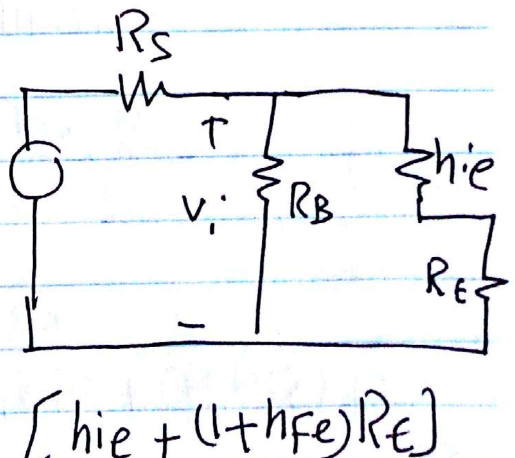
$$\therefore A_{vs} = \frac{V_o}{V_s} = \frac{V_o}{V_i} * \frac{V_i}{V_s}$$

$$V_o = -h_{fe} I_b Z_o$$

$$V_i = i_b \left[h_{ie} + (1+h_{fe}) R_E \right]$$

$$\therefore \frac{V_o}{V_i} = \frac{-h_{fe} Z_o}{h_{ie} + (1+h_{fe}) R_E}$$

$$V_i / V_s = \frac{R_B \parallel [h_{ie} + (1+h_{fe}) R_E)]}{[R_B \parallel (h_{ie} + (1+h_{fe}) R_E]] + R_s}$$



$$\therefore A_{vs} = \frac{-h_{fe} Z_o}{h_{ie} + (1+h_{fe}) R_E} * \frac{R_B \parallel [h_{ie} + (1+h_{fe}) R_E]}{R_s + [R_B \parallel [h_{ie} + (1+h_{fe}) R_E]}$$ #

to Find A_{is}

$$A_{is} = \frac{I_o}{I_s} = \frac{I_o}{I_b} * \frac{I_b}{I_s}$$

$$I_o = \frac{V_o}{R_L} \quad , \quad i_b = \frac{v_i}{h_{ie} + (1+h_{fe})R_E}$$

$$\therefore \frac{I_o}{i_b} = \frac{V_o}{V_i} * \frac{h_{ie} + (1+h_{fe})R_E}{R_L}$$

$$\frac{I_o}{i_b} = \frac{-h_{fe} Z_o}{\cancel{h_{ie} + (1+h_{fe})R_E}} * \frac{\cancel{h_{ie} + (1+h_{fe})R_E}}{R_L}$$

$$\boxed{\frac{I_o}{I_b} = \frac{-h_{fe} Z_o}{R_L}}$$

$$\therefore I_b = i_s * \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

$$\frac{i_b}{i_s} = \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

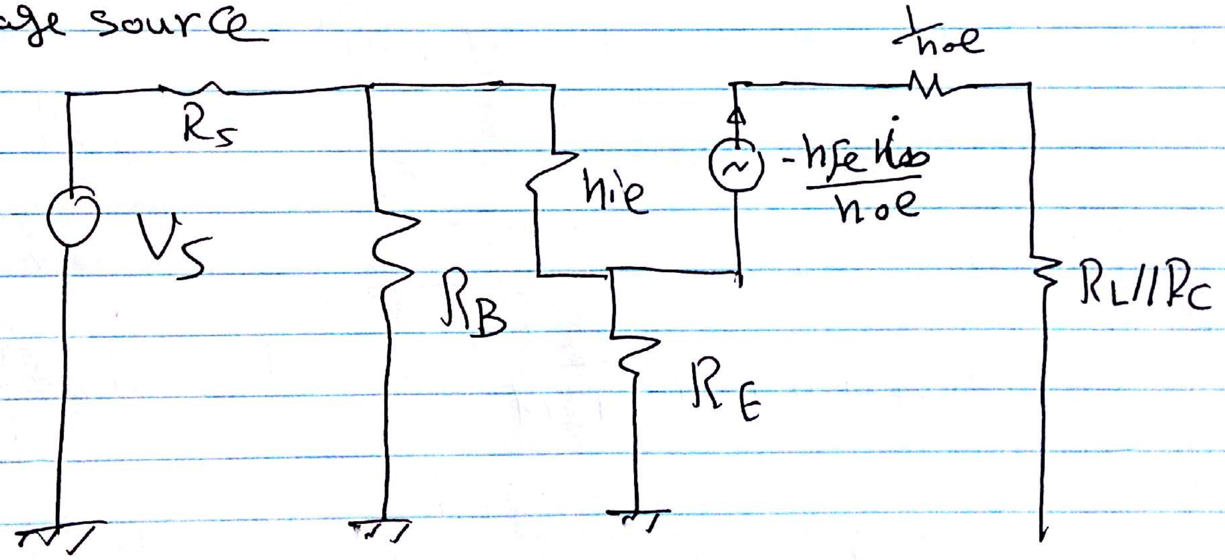
$$\therefore A_{vs} = \frac{-h_{fe} Z_o}{R_L} * \frac{R_B}{R_B + h_{ie} + (1+h_{fe})R_E}$$

when we taken the effect of $\frac{1}{h_{oe}}$

$$Z_{is} = R_S + \left[R_B // \left(h_{ie} + (1+h_{fe}) R_E \right) \right]$$

$$Z_o = R_L // R_C // \left[\frac{1}{h_{oe}} + (1+h_{fe}) R_E \right]$$

to find A_v :- convert the current source to voltage source



$$A_v = \frac{V_o}{V_i}$$

$$V_o = \frac{-h_{fe} i_b}{h_{oe}} * \frac{R_L // R_C}{(R_L // R_C) + (1+h_{fe}) R_E + \frac{1}{h_{oe}}}$$

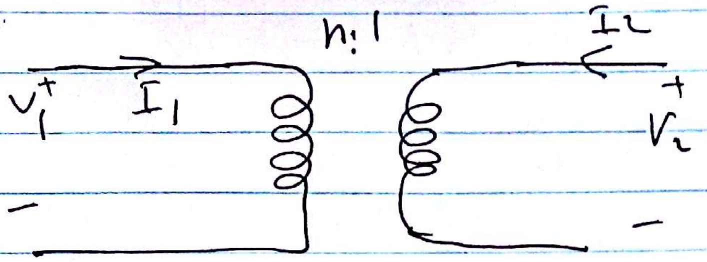
$$V_i = i_b \left(h_{ie} + (1+h_{fe}) R_E \right)$$

$$\therefore A_v = \frac{-h_{fe}}{h_{oe}} \frac{R_L // R_C}{(R_L // R_C) + (1+h_{fe}) R_E + \frac{1}{h_{oe}}} * \frac{1}{h_{ie} + (1+h_{fe}) R_E}$$

$$A_i = \frac{I_o}{I_b} = \frac{1}{\cancel{I_b}} * \frac{-h_{fe}\cancel{i_b}/h_{oe}}{\frac{1}{h_{oe}} + R_E(1+h_{fe}) + R_T}$$

$$A_i = \frac{-h_{fe}/h_{oe}}{\frac{1}{h_{oe}} + R_E(1+h_{fe}) + R_T}$$

② Find ABCD Parameter for the ideal Transformer



Solution

من خواص ال Transformer

$$V_1 = n V_2 \rightarrow ①$$

$$\frac{V_1}{V_2} = \frac{n_1}{n_2}$$

$$\frac{I_1}{I_2} = \frac{n_2}{n_1}$$

$$\therefore I_1 = -\frac{1}{n} I_2 \Rightarrow ②$$

$\because$
$$V_1 = A V_2 - B I_2$$
$$I_1 = C V_2 - D I_2$$
نقارنها مع ① ②

$$\therefore a_{11} = A = n, \ a_{12} = B = 0, \ a_{21} = C = 0, \ a_{22} = D = \frac{1}{n}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} n & 0 \\ 0 & 1/n \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$